R&D MANAGEMENT

The relationship of industry structure to open innovation: cooperative value creation in pharmaceutical consortia

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With its focus on value creation and value capture, open innovation research explicitly or implicitly examines the competitive impacts of collaboration. However, to date such research has not considered the effects of a blockbuster industry structure upon open innovation. Here, we examine a particular form of multilateral collaboration, the open R&D consortium, in which the results from collaboration are allowed to spill over to members and nonmembers alike. We do so in the context of the pharmaceutical industry, a stable but fragmented industry defined by the ongoing search for blockbuster hits protected by strong appropriability. Using a novel data set, we identify 141 such consortia that involve two or more of the 30 largest pharma firms. We show that firms financially support such consortia, in part, because their value creation activities benefit members without disrupting the value capture or other aspects of the incumbent industry structure. We discuss the implications of these findings for research on multilateral collaboration in blockbuster industries, and open innovation more generally.

1. Introduction

Within open innovation, there are many examples of distributed multilateral collaboration, including alliance networks, communities, ecosystems, platforms and consortia (West, 2014a). Such open innovation collaborations have been aided by the adoption of digital computing and communication technologies. In some cases, these technologies enable new forms of cooperation, such as open source software (O'Mahony and Ferraro, 2007) and online innovation contest (Ebner et al., 2009). In other cases, these technologies improve the efficiency and reach of such collaborations (Schmidt et al., 2008).

One example of such distributed collaboration is the research and development consortium. An R&D consortium – defined here as two or more organizations pooling resources to conduct collaborative research – has been around in the U.S. for over 30 years. In the best-known examples – e.g., MCC, SEMATECH – the consortium is like a club where members join to obtain preferential access to the knowledge and other outputs produced by the consortium (Sandler, 2002; Carayannis and Alexander, 2004).

However, in recent years, a newer form of consortium has emerged which allows freer spillovers beyond consortia members and thus can fuel market entry, commoditization and reduced profits for

member firms (West and Gallagher, 2006). These new arrangements heighten the tension between value creation and value capture found in older consortia. Specifically, organizers of a consortium now have to manage the trade-off between incentivizing potential members to engage in joint value creation when the returns may not only be captured unevenly by members but also may accrue privately to non-members (Chesbrough, 2006b; Simcoe, 2006).

To explore how firms are managing this tension, we study a new form of open consortia involving pharmaceutical companies. Although the largest pharmaceutical companies have historically succeeded based on their ability to create and protect patented and other proprietary technologies, in the past 20 years there has been an explosion of more than 300 biomedical R&D consortia – most organized to allow open spillovers. Our research question is: How do firms create and capture value through participation in these new open consortia?

To answer this question, we compare the activities of consortia in terms of providing opportunities for member firms to improve their value creation or value capture strategies. Based on a sample of 141 consortia related to clinical research, basic or applied science, we identify eight general types of open pharmaceutical R&D consortia. These types vary in terms of specificity of focus, in terms of structure and integration of the member organizations, and in terms of scope.

However, we find that generally member firms emphasize shared value creation over firm-specific value capture. Firms are willing to join consortia that create value without changing value capture, when the benefits of that value creation are likely to accrue to a stable oligopoly with proven value capture mechanisms. Beyond contributing to our understanding of value creation and value capture in consortia, these findings provide more general insights on how industry structure influences and moderates the impacts of open innovation – such as for other 'blockbuster' industries (cf. McGahan, 2000) that require large upfront investments with delayed and uncertain returns.

The remainder of the paper is organized as follows. The paper first presents a review of the literature related to multilateral collaboration and industry structure. After describing our methods and our sample, the paper describes the eight types of open innovation pharmaceutical R&D consortia, and discusses how these types vary in terms of value creation and value capture, structure and scope. The paper concludes with a discussion of the significance of the findings for open source collaboration, and more generally for open innovation and industry structure.

2. Prior research

A central question of open innovation is how a firm's business model helps it create and capture value from innovation (Chesbrough and Rosenbloom, 2002; Chesbrough, 2006b). Value creation and value capture represent fundamental issues for both a micro- and macro-understanding of organizations (Lepak et al., 2007). While in some contexts they occur simultaneously, often these are distinctive actions leading to situations where the organization that creates the value does not capture it. A major concern is 'value slippage', when the organization that creates value does not capture it (Lepak et al., 2007). This is of particular concern in strategic alliances, when partners must invest both in creating synergistic value and capabilities to capture value (Doz and Hamel, 1998; Panico, 2017).

We are interested in how such business models relate to two aspects of open innovation: multilateral collaboration and the role of industry structure. Most open innovation research has focused on bilateral cooperation between two organizations, but the core principles of open innovation can also be applied to creating and analysing multilateral collaborations (Vanhaverbeke et al., 2014). Such open innovation networks can include networks of bilateral alliances, ecosystems, platforms and consortia (West, 2014a). While open innovation can bring the business model into such research streams, it can learn from prior research on how collaborations are managed and why firms do (or don't) join (West, 2014b).

A particular form of network is the industrial research consortium, which can include both cooperation of multiple organizations with a central consortium, and also bilateral or multilateral alliances between consortium members on specific projects (Doz and Hamel, 1998; Doz, Olk, and Ring, 2000). Because the knowledge produced by consortia tends to be a public good (Tassey, 2000; Allarakhia and Walsh, 2011), consortia face challenges to their business models (West, 2007b). Thus, consortia in the late 20th century tended to provide preferential access and control of the benefits they create (Olk, 1999, 2002) – as with standardization consortia that help members make their own technology more valuable (Bekkers et al., 2002). This access was important with the SEMATECH consortium, formed as a partnership between the U.S. government and 14 U.S. semiconductor firms to help firms better compete with foreign firms outside the consortium (Spencer and Grindley, 1993; Carayannis and Alexander, 2004).

Such consortia change a pure public good to a club good – one where nonmembers are excluded from the good's benefits – thus allowing them to gain financial support by finely allocating costs and benefits among members (Sandler and Tschirhart, 1997; Sandler, 2002). Although restrictions to club members could conceivably be a restraint of trade that violates antitrust law, in the U.S., the 1984 National Cooperative Research Act allows members-only knowledge cooperation (Wright, 1986).

A newer approach is the open innovation consortium, in which benefits spillover to members and nonmembers alike, as with open source software. While similar to other collaborations, firms want to jointly create value to make the consortium successful and avoid intense competition that dissipates profits (Simcoe, 2006; West and Gallagher, 2006; Lazzarotti and Manzini, 2009); the openness and the multiparty structure introduce new dynamics to the ongoing tension between value creation and value capture and how firms manage it.

While research has examined how OI practices are different based on firm size (e.g., van de Vrande, et al., 2009), we are unaware of any research that examines how open innovation is impacted by industry structure. This gap is surprising given the long understood relationship between industry structure and the nature of competition (Porter, 1985), and that the interaction of OI and competition is a core question of OI (Chesbrough, 2006a; Chesbrough and Crowther, 2006). In particular, we know that the nature of the industry structure impacts how and if firms capture value from their innovation (Lepak et al., 2007; Pisano and Teece, 2007).

Here we choose to study the pharmaceutical industry, one with a high rate of innovation and relatively stable structure. Because of its large economic and societal impact, the industry has been frequently studied in previous research on innovation strategy and policy (e.g., Mowery and Nelson 1999). The dynamics of the industry have three important features that distinguish them from some (but not all) R&D-intensive industries:

2.1. Blockbuster industry

The pharmaceutical industry is a classic 'blockbuster' industry, one where (a) revenue comes from a series of major projects that require large upfront investments with uncertain delayed returns and (b) these risky investments provide both high entry barriers and allow for long-term persistence of supranormal economic returns (McGahan, 2000). For new pharma products, these upfront bets are $150–200 million and nine years of R&D prior to drug approval; however, amortizing both the cost of capital and the costs of failed drugs means that $0.9–1.2 billion in R&D costs must be recovered from each successful drug (DiMasi et al., 2003; DiMasi and Grabowski, 2007). With less than 1 in 1,000 compounds making it to market, investments returns are highly skewed: overall profits are supported by a handful of 'blockbuster drugs' that generate more than $1 billion in annual sales (Gassmann and Reepmeyer, 2005).

2.2. Centrality of patents

Such risky investments are made only in the presence of strong appropriability that protects investment returns (Martin and Scott, 2000). For the pharma industry, appropriability is provided by patents, and thus patents have been more important for pharmaceuticals than any other industry (Grabowski, 2003). Historically, the industry has followed a model of one patent, one product: when that patent expires, those product sales must be replaced with follow-on blockbuster hits (Ledford, 2011).

2.3. Stable industry structure

These high entry barriers and long product lead times mean both persistently high profit margins, and a slow rate of change despite various internal and external stocks (Roberts, 1999; DiMasi, 2000). As Malerba and Orsenigo (2002, pp. 667–688) summarize, 'the core of leading innovative firms and countries has remained quite small and stable for a very long period of time, but the degree of concentration has been consistently low'. In 2015, the top 30 Big Pharma companies accounted for a majority of near $1 trillion in global pharmaceutical sales, totalling $558 billion (Looney, 2016).

3. Research approach

Our research question focuses on the value creation and value capture strategies by firms participating in open consortia. We are interested in how open strategies operate in blockbuster industries, which depend on strong appropriability to protect the returns of the inherently risky bets. Because of the limited research, we seek to build theory through an exploratory design, as recommended by prior research (Eisenhardt and Graebner, 2007).

3.1. Context: open collaboration in pharmaceuticals

Since the mid-1990s, the pharmaceutical industry has faced both cost and innovation challenges, as firms spent more money on R&D and produced fewer approved drugs (Pammolli et al., 2011). The productivity crisis has been particularly acute for largest firms whose productivity is falling more rapidly than the industry as a whole (Munos, 2009). One major reason is what Scannell et al. (2012) term the 'Better than the Beatles' dilemma, as new drugs must compete with former blockbusters that are now off-patent and available at commodity generic prices.

In response to these pressures, pharmaceutical firms have increasingly used open innovation. For licensing, joint R&D efforts and other forms of bilateral collaboration, such collaboration is governed by contracts, intellectual property rights and other forms of strong appropriability (Gassmann et al., 2010; Bianchi et al., 2011; Mortara and Minshall, 2011). A different form of pharmaceutical open innovation is a new open model of R&D consortium, such as the Structural Genomics Consortium (Perkmann and Schildt, 2015).

Here we study a broad range of these latter collaborations. We consider all consortia joined the largest global pharmaceutical companies – mostly fully integrated pharmaceutical companies that fund the discovery, development, clinical trials for regulatory approval, manufacturing and marketing of their own proprietary therapeutic compounds. As such, we focus on vertically integrated firms that expect cooperation to provide advantages over proprietary internal efforts, rather than specialist firms that partner because they lack necessary complementary assets (Teece, 1986).

3.2. Methods

3.2.1. Data

This study is from a research project gathering data on multiparty R&D alliances in the pharmaceutical industry. As our level of analysis is the consortium, we compiled a database of all possible R&D consortia related to the development of biomedical products by consulting scientific journals (e.g., Perkmann and Schildt, 2015), industry publications, press releases and other Internet-indexed sources. Over all, we identified more than 450 consortia. To supplement these secondary data, we gathered interview data from select consortia to better understand how these consortia operate.

3.2.2. Sample

Because our primary interest is in how companies manage competitive dynamics within a consortium, we sought to identify consortia with members from among the 30 largest pharmaceutical companies – based on their 2015 global pharmaceutical revenues – with pharma revenues of $6–43 billion (Looney, 2016).[1] Using the secondary data, we identified 325 consortia that reported member firms; of these, 141 consortia involved two or more of the top 30 firms. The degree of involvement of these Big Pharma firms in consortia roughly corresponded to their revenues and R&D spending (Table 1).

We analysed the consortium's activities in the light of a standard definition of the major phases of the drug development process: basic science, drug discovery, pre-clinical research, clinical research, and post-approval activities (Ng, 2015), which largely parallel the value chain of a fully integrated pharmaceutical company (Grabowski, 2002). The largest number of consortia focus on clinical research (68), which corresponds to the most expensive part of the drug development process. Next most common were basic science (50) consortia, which correspond to previously studied pre-competitive R&D consortia. A total of 101 of the 141 consortia involved these two categories, including 17 that correspond to both. Thus, our sample (Table 2) includes the polar opposites that Eisenhardt (1989) recommends for exploratory, theory-generating research.

4. Analysis

We used our exploratory data to identify how the activities of the 141 consortia in our sample related to the value creation and value capture activities of the member companies. This included identifying the consortium's mission statement, its scientific or clinical emphasis, and any specific geographic emphasis (e.g., a city, state or country name in the consortium's name or its mission), as well as the scope and structure of the collaboration. We used an iterative process of classification and comparison, discussing the patterns among the researchers. We then used our interviews to interpret the differences identified from these data, and shared our initial analyses with key industry informants to improve the external validity of our conclusions.

4.1. Classification of consortia

We coded the 141 consortia in three stages. First, we looked at the value-creating activities. We found that the consortia helped drug development in five possible ways: speeding up development (of a drug, a technology or approval); sharing investments and risks; creating and disseminating knowledge

Table 1. Multilateral consortia activity by Top 30 pharmaceutical companies

Rank	Company	HQ	2015 Sales†	R&D (%)	Number of Consortia*
1	Pfizer	US	43.11	17.8	103
2	Novartis	Swiss	42.47	19.9	62
3	Roche	Swiss	38.73	21.8	55
4	Merck & Co.	US	35.24	18.8	15
5	Sanofi	France	34.90	16.2	76
6	Gilead Sciences	US	32.15	9.4	8
7	Johnson & Johnson	US	29.86	22.8	43
8	GlaxoSmithKline	UK	27.05	17.5	93
9	AstraZeneca	UK	23.26	24.1	84
10	AbbVie	US	22.72	15.9	35
11	Amgen	US	20.94	18.7	52
12	Allergan	US	18.40	15.1	4
13	Teva	Israel	16.98	9.0	9
14	Novo Nordisk	DK	16.05	12.6	17
15	Eli Lilly	US	15.79	28.4	76
16	Bayer	Ger.	15.56	16.6	36
17	Bristol–Myers Squibb	US	14.48	27.9	38
18	Takeda	Japan	12.57	22.1	36
19	Boehringer Ingelheim	Ger.	12.35	22.7	42
20	Astellas Pharma	Japan	10.94	17.9	24
21	Mylan	US	9.29	7.0	2
22	Biogen	US	9.19	21.9	19
23	Celgene	US	9.07	25.3	10
24	Merck KGaA	Ger.	7.69	18.9	71
25	Daiichi Sankyo	Japan	7.22	22.4	13
26	Valeant	Canada	7.01	4.8	0
27	Otsuka Holdings	Japan	6.73	23.7	7
28	CSL	Aus.	6.29	9.0	2
29	Baxalta	US	6.15	19.1	3
30	Shire	Ireland	6.10	14.5	13

†Revenues in billion USD; Revenues, R&D from Looney (2016).
*Membership in consortia that have two or more Top 30 pharma companies.

to improve quality and efficiency; creating technical standards and shared implementation; and exploring new products and new therapy; each is intended to create value for all of the participating members. However, as our interviews revealed, the consortia did not change the firms' business model of making high-risk, high-return R&D investments in search of blockbuster returns. That is, the focus of each consortium is more on value creation rather than on value capture. We concluded (and our informants agreed) that consortia participation thus did not change the overall value capture approach of the member firms. Consequently, we focused on value creation activities and classified a consortium based on its impact upon the companies' value creation. We divided the consortia into two groups based on their breadth of impact and then categories within each group:

- *Specific products/markets* (3 categories). For these consortia, the activities are oriented towards a specific subset of a company's products or markets. We found three categories: two related to the demand – a specific disease or family of diseases – and one related to supply, i.e., the technology being used. From our interviews, it was clear that the decision for a member firm to participate was usually based on an overlap between the consortium's and the firm's scope.
- *Industry-wide topics* (5 categories). In these consortia, activities relate to addressing a broader set of problems facing the industry. We identified five broad categories: safety, ICT standardization, running clinical trials, manufacturing and best practices. In these cases, the decision to join seemed driven by the perception of the unmet need or the likelihood of the consortium to address that need.

Table 2. Consortia involving basic, applied and clinical research

Founding date	Consortium name	Acronym	Big pharma members
2014	Accelerating Medicines Partnership – Alzheimer's		4
2014	Accelerating Medicines Partnership – Autoimmune		6
2014	Accelerating Medicines Partnership – Diabetes		5
1997	AERAS		2
2014	AETIONOMY		3
2003	Alzheimer's Association Research Roundtable	AARR	11
2004	Alzheimer's Disease Neuroimaging Initiative	ADNI	9
2002	Analgesic Clinical Trial Translations, Innovations, Opportunities, and Network	ACTTION	6
2012	Anti-Biopharmaceutical Immunization: prediction and analysis of clinical relevance to minimize the RISK	ABIRISK	7
2012	Asia Training Consortium	ATC	4
2010	Asian Cancer Research Group	ACRG	3
2011	Avoca Quality Consortium	AVOCA	17
2011	Be The Cure	BTCURE	6
2010	bioMARkers and molecular tumor classification for non-genotoxic CARcinogenesis		3
2006	Biomarkers Consortium	BC	13
2012	Biomarkers for Enhanced Vaccines Immunosafety	BioVacSafe	2
2006	Cardiac Safety Research Consortium	CSRC	11
1997	Clinical Data Interchange Standards Consortium	CDISC	17
2007	Clinical Trials Transformation Initiative	CTTI	8
2008	Coalition Against Major Diseases	CAMD	11
2013	Combating Bacterial Resistance in Europe	COMBACTE	2
2010	CommonMind Consortium	CMC	2
2011	COPD Biomarker Qualification Consortium	CBQC	4
2011	COPDMAP	COPDMAP	4
2012	Cross-Pharmaceutical Investigator Databank		4
2012	Diabetes Research on patient stratification	DIRECT	3
2011	DILI-sim Initiative	DILIsym	10
2011	Drug Disease Model Resources	DDMoRe	9
2003	Drugs for Neglected Diseases initiative	DNDi	12
2011	Electronic Health Records Systems for Clinical Research	EHR4CR	10
2009	EUROPAIN	EUROPAIN	7
2013	European Asthma Research & Innovation Partnership	EARIP	2
2012	European Autism Interventions	EU-AIMS	3
1994	European Bioinformatics Institute Industry Programme	EMBL-EBI	14
2008	European Gram Negative Antibacterial Engine	ENABLE	3
2013	European Medical Information Framework	EMIF	6
2002	Expression Project for Oncology	expO	5
2013	GetReal	GetReal	13
2013	Global CEO Initiative on Alzheimer's Disease	GCI	8
2013	Global Health Innovative Technology Fund	GHIT	7
2011	Green Park Collaborative	GPC	10
2010	Improving beta-cell function & identification of diagnostic biomarkers for treatement monitoring in diabetes	IMIDIA	7
2012	Indiana Biosciences Research Institute	IBRI	2
2002	Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials	IMMPACT	5

(Continues)

Table 2. (Continued)

Founding date	Consortium name	Acronym	Big pharma members
2010	International Consortium for Innovation and Quality in Pharmaceutical Development	IQ	22
2002	International Partnership for Microbicides	IPM	3
2001	International Pharmaceutical Aerosol Consortium on Regulation and Science	IPAC-RS	7
2007	International Serious Adverse Event Consortium	iSAEC	10
2011	Investigation of Serial Studies to Predict Your Therapeutic Response with Imaging And moLecular Analysis 2	I-SPY 2	5
2012	Investigator Databank		5
2013	Kidney Health Initiative	KHI	7
2011	Manchester Chemical Biology Network	MCBN	2
2012	Manchester Collaborative Centre for Inflammation Research	MCCIR	2
2009	Maturation & accelerating translation with industry	MATWIN	10
2007	Measurement and Treatment Research to Improve Cognition in Schizophrenia Consortium	10	
2011	Methods for systematic next generation oncology biomarker development	OncoTrack	7
2005	Microarray Quality Control Consortium	MAQC	6
2012	Multiple Sclerosis Outcome Assessments Consortium	MSOAC	6
2014	National Lung Matrix Trial	NLM	3
2009	Novel methods leading to new medications in depression and schizophrenia	NEWMEDS	5
2014	Osteoarthritis Biomarkers Project	OABP	4
2006	P1Vital CNS Experimental Medicine Consortium		2
2002	Parkinson's Disease Research Tools Consortium		6
2010	Parkinson's Progression Markers Initiative	PPMI	8
2014	Partnership to Accelerate Clinical Trials	PACT	3
2012	Partnership to Advance Clinical Electronic Research	PACeR	5
2009	Patient-Reported Outcomes Consortium	PRO	16
2013	Patients to Trials Consortium		3
2004	Personalized Medicine Coalition	PMC	14
2010	Pharma-Cog		7
2009	Pharmacoepidemiological Research on Outcomes of Therapeutics by a European Consortium	PROTECT	11
2009	Pistoia Alliance		12
2012	PK-PD platform 2.0	*PK-PD*	10
2010	Polycystic Kidney Disease Outcome Consortium	PKD	2
2014	PRECISESADS		3
2012	PreDiCT-TB		4
2006	Predictive Safety Testing Consortium	PSTC	16
2009	Progressive Multifocal Leukoencephalopathy Consortium	PML	3
2012	Project DataSphere		8
2011	Quantitative Imaging in Cancer: Connecting Cellular Processes with Therapy	QuIC-ConCePT	7
2008	Quebec Consortium for Drug Discovery	CQDM	7
2011	Relating Clinical Outcomes in MM to Personal Assessment of Genetic Profile	CoMMpass	4
2009	Safer and Faster Evidence-based Translation	SAFE-T	10
2013	Schistosomiasis treatment for preschool children	STPC	10
2007	Singapore Diabetes Consortium		3

(Continues)

Table 2. (Continued)

Founding date	Consortium name	Acronym	Big pharma members
2012	Stem cells for biological assays of novel drugs and predictive toxicology	StemBANCC	8
2010	Stratified Medicine Programme		2
2004	Structural Genomics Consortium	SGC	7
2009	SUrrogate markers for Micro- and Macrovascular hard endpoints for Innovative diabetes Tools	SUMMIT	6
2008	Telemetric and Holter ECG Warehouse	THEW	3
2002	The ILSI Health and Environmental Sciences Institute	HESI	19
2004	The Mondriaan Project	ICAV	10
2007	The RNAi Consortium		4
2018	Therapeutics Consortium		2
2008	Toll-like receptors: a target for many therapeutic applications		10
2012	Towards novel translational safety biomarkers for adverse drug toxicity		10
2012	TransCelerate Biopharma Inc		15
2013	TRANSLOCATION		3
2013	TranSMART Foundation		5
2009	Unbiased BIOmarkers in PREDiction of respiratory disease outcomes	U-BIOPRED	7
2011	WIPO Re:Search		6

Second, to consider implications beyond this industry and sample, we performed an analysis based on the scope and, third, on the structural relationships between the consortia and their members. The categories used are summarized in Table 3.

4.1.1. Scope

Alliance scope represents a fundamental dimension for understanding alliances. Oxley and Sampson (2004), for example, in their study of R&D alliances noted that the critical decisions of defining the governance structure and of the scope of the alliance are not only complementary decisions, but of particular concern for knowledge sharing in competitive contexts. We also focus on scope because early research into R&D consortia (e.g., Aldrich and Sasaki, 1995) noted that consortia varied in terms of the problem each consortium addressed, with some consortia addressing broad issues (e.g., computer technology; semiconductors) while others brought together companies around a more specific research topic.

4.1.2. Structure

Since consortia are an alliance structure, we draw from the common distinction in alliance literature which separates different governance structures in terms of the degree of integration among members (e.g., Nooteboom, 1999; Teng and Das, 2008). As shown in Table 3, in our sample, we found five structures reflecting variations in member integration. In the least integrated form, Donor structure, members only donated resources to another organization to conduct the R&D. Other structures (in increasing order of integration) are the *Exchange* structure, the Guiding structure and the Distributed Research structure. The most integrated form is the Centralized Research structure, which involves the member companies creating and staffing a new organization.

The findings for the eight categories are summarized below and are reported in Tables 4 and 5. Table 4 provides examples of each and provides quotes that illustrate the category. Table 5 reports the coding of each category in terms of how value is created, the consortium's scope and its structure.

4.2. Specific conditions and technologies

Sixty-four of the 141 consortia were organized around either a specific disease (N = 41) or a family of related diseases (N = 23), typically defined by the affected organs (e.g., nervous system, respiratory system) or the signs and symptoms of the body's reaction to disease (e.g., inflammation or pain).

In most cases, we found that firms in these consortia were attempting to complement internal activities since most already had products currently being sold or under development for the associated therapeutic area.[2] This investment only loosely related to current market sales. For example, the two largest segments

Table 3. Definitions of scope and structural arrangements

Scope	***Unitary:*** The consortium reports working concurrently on only one project ***Multiple:*** The consortium reports working concurrently on more than one project
Structure	1. ***Donor:*** Members fund research in an existing, nonmember organization (e.g., university). This structure will likely be high in value creation within the existing organization. However, because the R&D will be conducted elsewhere, and likely by nonmember organization researchers, there is a low likelihood that the member organizations will capture significant value from the consortium 2. ***Exchange:*** Members post or share data to a central exchange or a separate organization. The members are then able to access and analyse other firms' data but the results are typically not shared. This structure will create some value, as members are able to gain insights from seeing the other members' data. Similarly, member organizations should capture some value since they are the ones who typically access the data and do the analysis internally. 3. ***Guiding:*** Members create a small consortium with a headquarters that then coordinates members' activities around developing standards, common frameworks or guidelines, or promote the adoption of a common practice. Value creation is moderate for this collaboration since the consortium focuses on streamlining activities – e.g., created standards, development of frameworks, establishing guidelines. Such streamlining or guiding activities reduce uncertainty for member organizations and create value. Value capture is less specific to the companies since this knowledge developed by the consortium is typically shared with all the members and, typically, nonmembers. 4. ***Distributed Research:*** Members create a small consortium with a headquarters that oversees the collaboration conducted within member organizations and then is shared with others. In this structure, value creation potential will be high since the consortium is engaging in coordinated research. It may not be as high as in *Guiding* since the research is conducted in multiple locations. However, value capture should be high for the member organizations because they are conducting some of the research in-house and will be able to share internally whatever value is created. 5. ***Centralized Research:*** Members create a central organization that has researchers who conduct value-creating activities. Although the most expensive, this structure can create a high amount of value since (as with *Guiding*) the researchers are located in a single organization. Firms can potentially transfer more technology and capture more value than *Guiding* if the research is done by researchers seconded from the member organizations, or if the consortium coordinates its research strategy with members' research.

of the global pharmaceutical industry remain cancer and diabetes, respectively, accounting for 8.3% and 7.5% of global pharmaceutical sales in 2015 (Loo, 2016). However, while 11 consortia were directly about cancer, only 4 related to diabetes.

Within the 64 consortia organized around disease, we found three common patterns of value-creating activities.

4.2.1. Basic research

In some consortia, members shared investment in the basic science about root causes or symptoms of a human pathology, the mechanisms of action or opportunities to disrupt or block such pathologies. This is particularly true for poorly understood complex diseases, such as late onset neurodegenerative diseases such as Alzheimer's and Parkinson's, which have only 10% of the drug sales of cancer and diabetes, but together account for 9 consortia.

4.2.2. Diagnostic biomarkers

For 15 consortia, the cooperation includes developing accurate biomarkers for measuring disease progression. These biomarkers measure both a disease's direct effects (e.g., inflammation), and proxies current or future outcomes (e.g., cholesterol as a predictor of heart attacks). Biomarkers are used by clinicians to diagnose new or chronic cases of a disease, normally as diagnostic products that have completed regulatory approval. The same biomarkers can also be used by drug companies to monitor the progress of clinical trials of their therapeutic products and to establish clinical efficacy when seeking regulatory approval for these products. For example, three of the Alzheimer's and respiratory disease consortia seek to develop biomarkers. As one pharma exec noted, one of the challenges in getting new Alzheimer drugs approved is because 'we don't have the research tools of how to measure Alzheimer's diseases … nobody can [solve] it by themselves'.

4.2.3. Clinical observation and treatment

In some cases, consortia seek to provide access to a pool of patients with the associated condition, particularly for diseases that require longitudinal observation of a large cohort of patients. Examples of these include ADNI for Alzheimer's or DIRECT

Table 4. Eight categories of consortia classification

Breadth of impact	Category	#	Examples	Quotes
Specific products/ Markets	Disease	41	ADNI, COPDMAP, OncoTrack, Singapore diabetes Consortium	'We don't have the research tools of how to measure Alzheimer's diseases … nobody can [solve] it by themselves'. (Interview, 23 Nov 2016)
	Family of diseases	23	AETIONOMY, Coalition against major diseases, Kidney health initiative	'By facilitating ongoing, iterative dialogue and interaction between the FDA and kidney community stakeholders, KHI [Kidney Health Initiative] is poised to help identify specific instances of these challenges with respect to kidney health and provide a forum to develop solutions'. Archdeacon et al. (2013, p. 5)
	Other technology	9	IPAC-RS, Microarray quality control consortium	'IPACT-1 representatives visited the world's health authorities and eventually developed a strategy that would in one program satisfy the requirement to generate a single excipient master file that all member companies could reference for their specific drug applications'. Leach (2005)
General processes	Safety, toxicity and side effects	13	iSAEC, PROTECT, ABIRISK, Cardiac Safety Research Consortium, ELSIE	'The CSRC is/has impacted the approaches to CV [cardiovascular] safety of drug development in many areas: QTc, oncology drug development, new approaches, adjudication of CV events, the role of large CV outcome studies for safety, BP assessment, etc'. (Email, 11 Oct 2015)
	Data or IT standards	13	Clinical data interchange standards consortium, Pistoia alliance, Transcelerate	'We use pre-competitive collaboration to address issues around aggregating, accessing, and sharing data that are essential to innovation, but provide little competitive advantage' Pistoia (2017).
	Clinical trials	11	Avoca quality consortium, Clinical trials transformation initiative, Partnership to accelerate clinical trials	'The AQC [Avoca Quality Consortium] brings together pharma, biotech, and clinical service companies that share a commitment to collaboratively improving the execution and management of outsourced trials'. (Presentation, 10 May 2016)
	Manufacturing	9	BioMAN, Rx-360	'Pharma is very competitive, very proprietary, everyone thinks they're the smartest people in the world…People think they're so different but they do it exactly the same way'. (Interview, 27 July 2017)
	Other standards and best practices	8	Biomarkers consortium, IQ	'It represents a new step in sharing both the burdens and the fruits of fundamental scientific work' Leavitt (2006)
	Other	14	Personalized medicine coalition, Structural genomics consortium	'The real benefit to industry is the ability to nominate targets' Perkmann and Schildt (2015).
Total		141		

for Type 2 diabetes. For breast cancer, I-SPY 2 was the first to use a randomized clinical trial to compare the efficacy of multiple treatments using the same metrics, and providing data to all sponsoring firms (Barker et al., 2009). It was initially funded not only by companies that had drugs in the study, but also by other companies (as one former corporate member put it) 'because there is something explicitly interesting that [we] would love to know the answer to'. In some cases, these studies are run or led by a specific university, as when the University of Birmingham lead the National Lung Matrix trials in the U.K. for non-small cell lung cancer.

As one might anticipate, consortia focused on a specific disease generally have a different scope than those investigating a family of diseases. The former adopts primarily a unitary scope, addressing a single project focused on the disease, while the latter has a broader scope, simultaneously addressing multiple

Table 5. Consortia coded by value creation, dominant scope and dominant structure

		Primary value creation benefits					Dominant scope		Dominant structure(s)				
Breadth of impact	Category	Speed up development of drugs, tools, or research	Share resource, investment, or risks	Create & disseminate knowledge about quality and efficiency	Create technology standards	Explore new products	Unitary	Multiple	Donor	Exchange	Guiding	Distributed	Centralized
Specific Products/ Markets	Disease	X	X				X			x	x	X	
	Family of diseases	X	X					X	x	x	x	X	
	Other technology		X				X						X
General processes	Safety, toxicity and side effects		X					X			X		
	Data or IT standards			X	X			X	X		X		
	Clinical trials		X				X	X			X		
	Manufacturing				X		X	X	x	x	x	x	
	Other standards and best practices				X		X	X			X		
	Other					X	X	X			X	X	
Total													

(X = Primary benefit, scope or structure; x = prevalent but not primary consortium structure).

projects. The most common structure for these consortia is Distributed Research, but we also observe Exchange and Guiding.

4.2.4. Specific technologies

In addition to consortia that focus on specific diseases, nine consortia focus on developing or improving a specific technology. This includes three for stem cells, RNA interference (RNAi), and a class of proteins known as toll-like receptors. Meanwhile, the Microarray Quality Control Consortium promotes a specific technology for genomic sequencing, while IPAC-RS focuses on aerosol propellants for inhaled therapies for asthma and other respiratory diseases. As expected, these consortia primarily have a unitary scope, and have a more centralized structure.

4.3. General medical problems: safety, toxicity and side effects

While the plurality of consortia focus on a particular medical need and an associated therapeutic area, other consortia focus on broader needs. Thirteen such consortia focus on minimizing adverse effects from therapeutics, including toxicity, and other side effect and safety concerns.

Three consortia consider general issues of adverse effects. For example, The Predictive Safety Testing Consortium seeks to anticipate adverse effects, while PROTECT and iSAEC seek to compile reports of adverse effects of products after they have been put into use. Other consortia look at particular types of side effects – such as immune responses and carcinogenesis – or damage to specific organs like the heart or liver. Most of these consortia addressed more than one project at a time, adopting a broader scope. Reflecting the focus on reducing problems and developing shared best practices, the Guiding structure is the dominant pattern, creating value for both member and nonmember firms by limiting any adverse effects.

4.4. General purpose technologies: ICT standardization

In contrast to technologies associated with specific medical products, Information and Communication Technology (ICT) standards constitute general-purpose technologies that enable a wide range of products, industries and technologies. ICT cooperation in our sample is organized around the idea that – as Carr (2003) famously noted – 'IT doesn't matter' when it comes to competitive advantage. One example is the Pistoia Alliance, founded in 2009 by representatives of 4 of the 10 largest pharma companies. Led by IT managers, its stated mission is to 'address issues around aggregating, accessing, and sharing data that are essential to innovation, but provide little competitive advantage' (Pistoia, 2017).

Thirteen consortia focus on data and other ICT standardization. The oldest is the Clinical Data Interchange Standards Consortium, founded in 1997, which has worked to cooperate with various other consortia and industry groups defining standards for measuring and representing data regarding clinical (patient) outcomes and clinical trials. Similarly, additional consortia (e.g., Electronic Health Records Systems for Clinical Research) seek to improve the interoperability of data from electronic health records, while others (e.g., Transmart) are organized to create a shared system for clinical data.

These consortia almost always pursue a broad scope, managing multiple projects. The structure are mostly Donor, where the firms could use an existing organization to coordinate activities, and Guiding, where member organizations seek to establish standards or guidelines.

4.5. General operations: clinical trials and manufacturing

4.5.1. Clinical trials

Clinical trials, as noted earlier, are the longest and most expensive phase of the drug development process. Eleven consortia focus on making clinical trials more efficient by sharing information or standardizing clinical trial processes.

The most popular is the Avoca Quality Consortium (17 Big Pharma members), which is dedicated 'to collaboratively improving the execution and management of outsourced trials'. Meanwhile, the Patients to Trials Consortium is an online platform funded by Eli Lilly, Novartis and Pfizer to provide a standardized process for recruiting patients to clinical trials. The focus of these consortia on standardizing or speeding up the clinical trial process means that most use a Guiding structure.

4.5.2. Manufacturing

Besides establishing expectations for how to conduct clinical trials, the regulatory environment also affects the manufacturing standards. Pharmaceutical companies face similar challenges regarding the manufacturing of drugs, and nine consortia relate to improving the quality and efficiency of drug manufacturing.

The most popular, Rx-360 (18 Big Pharma members), is dedicated to assuring the quality of inputs

provided by suppliers to pharmaceutical manufacturers. It was organized in response to more than 100 deaths in 2008 due to a counterfeit ingredient used by Baxter International to manufacture its Heparin blood thinner. Likewise, Adventitious Agent Contamination in Biomanufacturing allows members to confidentially share and compare experiences with contamination in manufacturing biotech products. These manufacturing-related consortia do not have a singular scope or common structure approach to how they organize to create value: both unitary and multiple project scopes are represented and each of the structure types is identified.

4.6. General standards and best practices

Eight of the remaining consortia focus on other aspects of standardizing scientific measurement or other aspects of drug discovery best practice. For example, GetReal has a specific mission to bring 'real world evidence' into the development, clinical testing and post-testing adoption of new medicines. Alternatively, The Biomarkers Consortium is a public–private partnership between pharmaceutical companies and the NIH to fund scientific studies to identify and validate new biomarkers, across several areas, including cancer, inflammatory (e.g., arthritis), metabolic diseases (e.g., diabetes) and neuroscience. The scope of these consortia includes both those focused on a single project and those engaged in multiple projects. Most consortia in this category use the Guiding structure to organize.

4.7. Patterns of consortia scope and structure

Examining the patterns across the different categories reveals additional insights into the organizing approach pharmaceutical firms are using to create consortia. In examining scope, it is clear that firms are creating both broad-scoped alliances as well as more narrow ones. For the nine categories of consortia, six showed prevalence of unitary-scoped alliances, while seven showed multiple-scoped alliances. While some categories (e.g., Disease; Family of Diseases) had predominantly only one type of scope, several (e.g., Clinical Trials; Manufacturing) had both. In examining the overall patterns, the choice of the scope of the consortium does not appear to be related to the breadth of impact.

For structure, our data again revealed variations in the structural forms for organizing consortia, but with the prevalence of the Guiding structure. Consortia focused upon diseases were most likely to use Distributed Research as the primary structure, but there was also evidence of each of the other structural types.

For the general process consortia, however, the primary structure was Guiding. While this structure created value from a focus on standardization or on creating a consensus on how to address a common problem, the emphasis is less upon value capture by the firms. Instead, these collaborations are viewed as creating public good that will benefit others – members and nonmembers alike. In terms of scope, these consortia were slightly more likely to be multi-project than unitary.

Finally, examining the patterns across value creation benefits, scope and structure did not reveal any consistent relationships among the three consortium attributes. The choices about how to create value does not appear to depend upon only one type of scope or structure, and vice versa.

4.8. Effect of industry structure on value capture

Earlier open innovation research has suggested a tension between value creation and value capture activities in multilateral open innovation cooperation (Simcoe, 2006; Chesbrough and Appleyard, 2007). While some consortia historically provide preferential knowledge access that increased value capture by members over nonmembers (Carayannis and Alexander, 2004), member value capture is more difficult for those consortia that allow open spillovers to nonmember companies (West and Gallagher, 2006).

Beyond consortia that ran clinical trials on specific drugs, we saw little effort to provide such preferential access to members – enabling free-riding by nonparticipants. As one executive admitted, 'There are free riders who have less of an incentive to join because it [is published] anyway'.

Based on interviews, mission statements and other consortia policies – and confirmed through consultation with industry managers – we identified five reasons for Big Pharma firms to emphasize value creation rather than value capture in consortia. Four factors relate to the structure and nature of competition between these major firms.

4.8.1. Rising tide lifts big boats

The largest firms saw enough benefits for themselves that it didn't matter what benefits other firms realized. As MacKie-Mason and Netz (2007) noted for the participation in standards consortia by large IT companies such as IBM and Intel, a standard that helps the industry sell more products or reduce its costs is going to produce the most benefits for the large vendors in that industry. In addition to

standardizing IT format and best practices, our pharma sample also saw such 'rising tide' benefits for consortia that advance the science, whether for a specific medical problem, technology or side effect. An extreme example of such benefits was seen in the Genetic Association Information Network, where Pfizer spent more than $20 million (without support from other Big Pharma firms) to understand the limits of genome-wide association studies. This motive is reflected in the high frequency of the Guiding structure among the general process consortia.

4.8.2. Open science norms

Many firms were represented by scientific or clinical researchers who publish their medical research through the norms of open science (cf. Cook-Deegan, 2007). For the basic science consortia, such open dissemination of results was an explicit founding goal of the consortium: for example, upon formation of the Biomarkers Consortium, the sponsoring cabinet secretary announced that the consortium 'can help identify areas of opportunity, clarify responsibilities, and make important new findings openly available' (Leavitt, 2006).

4.8.3. PR benefits for incumbents

In response to pressure from regulators, payers or politicians, Big Pharma companies appear to have a tendency to endorse open efforts to improve public health (e.g., Reich, 2002). As one executive who worked at several companies said, 'Larger companies tend to be more joiners, because they have more resources and also because they're in the public eye'. Several respondents pointed to Pfizer – the top pharma company by 2015 revenues – which was the most active of any company.

4.8.4. Industry structure unchanged

More than a decade of consortia showed that spillovers or other consortia activities did not undercut the industry's fundamental barriers to imitation and barriers to entry. Firms continued to identify their own unique therapeutic compounds and obtain temporary IP and regulatory monopolies for these compounds. Consortia reduced the cost and time for existing companies to develop a new drug, but not enough to eliminate these as formidable barriers to new entrants. And nothing in the efforts of these consortia impacted a final entry barrier: the proprietary channels for distributing drugs to individual health care providers, which (particularly in the U.S.) requires a large and expensive sale force.

Unlike with open source software (Dahlander, 2007) and even hardware (Greul et al., 2017), these open spillovers tend to reinforce rather than disrupt the existing industry structure. However, a fifth factor was unrelated to industry structure.

4.8.5. Hard to block spillovers

Consortia face practical difficulties in blocking spillovers to nonmember companies, either in terms of the effectiveness or the necessary transaction costs. From our interviews, this seemed to be a lower priority than the other reasons – but we believe it helped discourage efforts by most consortia to pursue such efforts. In those few consortia that did have preferential access, this appeared driven by the business model of the consortium – as with ELSIE, which restricted data access to force firms to pay to support the consortium.

Seeking to evaluate the generalizability of these findings to other industries, we found examples that both supported and contradicted these findings (Table 6). Our most anomalous findings appear to be that of the open science unchanged industry structure: the 'rising tide' belief appeared to depend on an unchanged industry structure. For the two remaining motives, prior research seemed to suggest intermediate (or heterogeneous) views. Future research

Table 6. Motives for supporting multilateral collaboration without value capture

	Evidence from other sectors and industries	
Motive	Confirmatory findings	Contradictory findings
Rising tide lifts big boats	Personal computing MacKie-Mason and Netz (2007)	Weakest firms helped the most Berman (1990)
Open science norms	Firms with strong ties to academic institutions† Simeth and Raffo (2013)	Rent-seeking and trade secrets: telecommunications Bekkers et al. (2002)
PR benefits	Open source software Dahlander and Magnusson (2008)	Openness hurts stock price: open source software Alexy and George (2013)
Industry structure unchanged	Automotive industry Rycroft and Kash (2004)	Changes industry structure: open source software Gruber and Henkel (2006), mobile phones Fan (2011), 3D printing Greul et al. (2017)
Hard to block spillovers	Open source software West and Gallagher (2006)	Members gain advantage: SEMATECH Spencer and Grindley (1993)

†Sample included pharmaceutical firms, which had highest support for open science.

should further explore the applicability of these explanations.

5. Discussion

This exploratory study examined the tension between shared and private objectives of proprietary firms joining open consortia. On the one hand, cooperation makes shared value creation possible; on the other hand, the firms need to capture private value or they won't participate in such efforts (Simcoe, 2006). The stakes for success and failure are higher for firms that can obtain increasing returns to scale if they achieve blockbuster payoffs for their large and risky upfront investments (Arthur, 1996; McGahan, 2000). We evaluated this tension in a unique context – open R&D collaborations within the pharmaceutical industry, an industry not known for open collaboration. The findings from our study make several contributions to the understanding of the relationship between value creation, value capture and industry structure to consortia and other forms of multilateral open innovation.

5.1. Industry structure, value capture and open innovation

The traditional consortium business model is a club good, in which members fund the production of knowledge that's only available to dues-paying members (Carayannis and Alexander, 2004; West, 2007b). Without such preferential access, open consortia face challenges in attracting members and thus creating a viable business model. Traditionally, obtaining tacit knowledge has been an important benefit for member firms to participate in consortia (Blind and Gauch 2009). However, information that is digitalized is inherently codified (i.e., non-tacit) information (Sambamurthy et al., 2003), and such knowledge is more likely to spillover to third parties (Cowan et al., 2000). Thus, the greater the dependence on digitalization, we would expect a reduction in the incentive that tacit knowledge provided for joining (rather than free-riding) a consortium.

Consortia with open spillovers enable excess entry and thus potentially lead to commoditization of the industry. Prior research on open consortia has emphasized firms in the ICT sector such as software, telecommunications and computer systems vendors; like pharmaceuticals, the software industry rewards successful products via increasing returns to scale (Arthur, 1996; Antweiler and Trefler, 2002). However, ICT vendors can capture value from open consortia outputs by combining them with their own proprietary components (West, 2003, 2007a). Unlike such industries based on complex systems products, the appropriability mechanisms and business models are very different for industries that sell discrete products – exemplified by pharmaceuticals (Cohen et al., 2002).

In our study, pharmaceutical companies practiced open innovation through collaborative value creation, seemingly at odds with their traditional proprietary IP and vertically integrated value chains. Our data suggest that these companies can be open – and may have practical or even moral reasons for being open – without jeopardizing their fundamental business model: firms are willing to cooperate on value creation *precisely because* of their strong appropriability in their discrete products. We believe this cooperation is due to the high-cost/high-risk/high reward nature of the pharmaceutical industry, the quintessential example of what McGahan (2000) defines as a 'blockbuster' industry.

In this regard, we find the mechanism for value capture in pharmaceutical consortia is dramatically different than previously studied open consortia (e.g., West and Gallagher, 2006). In these complex products industries, the cooperation produces a portion of the firm's primary value creation activities. Particularly in open source software, cooperative value creation can lead to commodity competition and thus carries the risk of excess entry that diminishes or even eliminates value capture. This commoditization forces firms to seek other layers to add on top of the commoditized components – an exercise that may or may not be successful (O'Reilly, 2004; West, 2007a). Open source software also enabled entry by firms and thus changed the industry structure (Gruber and Henkel, 2006). Meanwhile, standardization of mobile telecommunications by standards consortia enabled a shakeout that rewarded low-cost over differentiation strategies, allowing Chinese manufacturers to supplant many of the European and North American firms who created the industry (Giachetti and Marchi, 2010; Fan, 2011).

However, openness works differently in blockbuster industries with discrete products protected by high barriers to entry and imitation that mean that blockbuster returns are not competed away. Thus, new consortia do not impact industry structure because the barriers are high enough that the rate of entry and the number of competitors are largely unchanged. Meanwhile, because reducing development time both saves costs and increases revenues (Paul et al., 2010), companies participating in open

consortia realize benefits from value creation that does not increase market entry or (thus far) industry rivalry.

5.2. Scope and structure of multilateral collaboration in the digital age

Beyond tracking value capture strategies, a unique feature of this study is that it examines how leading firms in the same industry repeatedly cooperate via consortia. Our focus on the scope and structure of collaborations involving at least 2 of the 30 largest pharmaceutical companies showed both unitary and broad-scoped consortia, and revealed a range of organizing structures (Table 3), although the most common was a small consortium headquarters that we term Guiding.

These results contribute to earlier research on inter-organizational collaborations (e.g., Olk, 1998; Ring et al., 2005). First, the finding that firms familiar with one another form broad-scoped alliances is novel. Earlier research has argued that high familiarity among potential member companies – gained either through being in the same industry or having partnered together earlier – is associated with more narrowly scoped consortia (e.g., Aldrich and Sasaki, 1995). In forming an additional consortium, familiar, networked firms can opt for a narrow scope since existing or new collaborations can address related problems. Here, however, we see that pharmaceutical companies have created both narrow and broad-scoped consortia. This suggests that even though these firms have collaborated and are in the same industry, there is relatively greater diversity among pharmaceutical companies, and more of a need for knowledge creation and sharing, than firms in other industries (e.g., telecommunication; semiconductors).

Second, our discovery that the Guiding consortium structure was the most prevalent is not consistent with the dyadic alliance research which shows that prior collaborations reduce the need for formal governance (e.g., Faems et al., 2008). The Guiding structure is in the middle in terms of the degree of formal member integration. That it was more common than less integrative structures may suggest a limit to the degree to which familiarity affects formal integration. While beyond the scope of this study, research should explore these findings to determine the extent to which they reflect the multiparty nature of these consortia, the value creation and value capture approaches of a consortium, or some unique characteristics of the pharmaceutical industry (e.g., knowledge diversity), and the implications this has for strategic alliance research.

5.3. Future research

In addition to the earlier suggestions, our study's findings offer broader implications for research on the role of appropriability in open innovation, which has largely been influenced by ICT studies. In pharmaceuticals, the need to obtain value creation does not require surrendering value capture (unlike Simcoe, 2006), while practicing open innovation with strong appropriability reinforces the industry structure – unlike the new component-based business models in complex ICT systems (West, 2006). Here strong appropriability is rewarding open innovation by incumbents, unlike the benefits that accrued to new entrants in the complex systems studied by Zobel and her colleagues (2016).

While we agree with Simcoe (2006) that consortia participation requires some form of rent capture to attract members, further research is needed to see if (unlike here) there are examples of open consortia without rent-seeking where membership *increases* value capture. While our study hints at the benefits of open collaboration in blockbuster industries, future research is needed to see how broadly applicable this is to other blockbuster industries. At the same time, our study hints at the challenges of measuring the benefits accruing from open collaboration, when they are indirect or subtle effects – such as through tacit knowledge or other transient competitive advantage – rather than overt rent-seeking (cf. Bekkers and West, 2009).

Pharmaceuticals is not the only discrete product industry with blockbuster returns protected by high barriers to entry and imitation. Thus, researchers could examine multilateral collaboration in other (McGahan, 2000) blockbuster industries such as movies, videogames and mineral exploration.

Finally, we believe this points to the ongoing need for more studies not only contrasting the differences in appropriability mechanisms between discrete and complex industries – as ably summarized by Cohen et al. (2002) – but to understanding the moderators of when these differences lead to very different outcomes that make it difficult to compare policies and strategies between such industries.

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Notes

1. The results were unchanged if we instead selected the top 50 firms. The top 30 (or 50) firms included the largest fully integrated biopharmaceutical company (Amgen), as well as firms such as Gilead, Roche and Sanofi with both types of products.
2. Our interviews suggested two categories of exceptions: first, investment in scientific fields where they had a possible future interest; second, for the largest firms, their slack allowed them to contribute to a scientifically interesting project with no direct business implications (with their funding amounting to a *de facto* charitable donation).

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